Excerpt from Japanese Patent Laid-Open Publication No. Hei 9-61843

[0006]

[Problems to be Solved by the Invention]

As described above, in a pulse beam having energy distribution which is formed in a rectangular shape, there always exist a region in which the energy distribution is uniform and a rising or falling edge region of the energy distribution. When the pulse laser beam having such energy distribution is scanned to execute laser annealing, both a region in which uniform energy reaches a film to be annealed and the falling edge region of the energy distribution (i.e. a region in which effective reached energy is on the decrease) inevitably exist, with the result in that the characteristics of the annealed film vary with a cycle equal to a scanning pitch of the laser beam. When a TFT array to be used for a liquid crystal display apparatus is produced using such an annealed film, TFT characteristics (such as electron mobility) vary according to the scanning pitch of the laser beam. When a driving circuit-integrated liquid crystal display apparatus is, in turn, produced using such a TFT array, the characteristic variation leads to an image unevenness in a display region. Further, in the driving circuit, driving capability varies, which manifests in the form of periodic unevenness on the images. Accordingly, display quality significantly declines.

[0008]

Further, the third object of this invention is to provide a

method of manufacturing a liquid crystal display apparatus in which display quality can be improved by suppressing characteristic variation due to a scanning pitch of a laser beam applied to a semiconductor thin film used for an active layer of a thin film transistor for driving to be formed on the periphery of a display region to make characteristics of a driving circuit uniform.

[0015]

Further, in the method of manufacturing a liquid crystal display apparatus, by using a pulse laser beam whose energy distribution is formed in a linear shape to anneal a semiconductor thin film which forms a thin film transistor for driving formed on the periphery of the display region, making a scan pitch of the pulse laser beam smaller than the length of the falling edge region of energy in a shorter side direction of the pulse laser beam, and setting a scan direction to be different from a channel width direction of the thin film transistor for driving, a beam overlapping region is generated in at least a part of the semiconductor thin film in the thin film transistor for driving to significantly reduce characteristic variation of a thin film transistor for pixel and reduce nonuniformity in the characteristics of the thin film transistor for pixel, with a result that display quality can be improved.

[0022] [Third Embodiment]

Fig. 3 is a drawing for explaining the method of manufacturing a liquid crystal display apparatus according to a

third embodiment of this invention and is a layout plan view showing a one-pixel segment in a TFT array of a liquid cryotal display apparatus. In Fig. 3, reference numeral 21 represents a source line, reference numeral 23 represents a gate line, reference numeral 25 represents a pixel electrode, reference numeral 26 represents a TFT (thin film transistor), and reference numeral 27 represents a polycrystalline silicon thin film.

[0023]

In the third embodiment, a pulse laser (XeCl: excimer laser) beam having energy distribution formed in a linear shape is used as is the case with the first embodiment. By scanning the pulse laser beam to crystallize a semiconductor thin film, a polycrystalline silicon thin film 27 of the TFT 26 in the TFT array of the liquid crystal display apparatus is formed.

[0024]

The pulse laser beam has the size of 180 mm in the longer side direction and 0.5 mm in the shorter side direction. The shorter side direction is established in parallel to the source line 21 and the semiconductor thin film is scanned with a pitch of 21 µm. An average number of irradiations is 23.8 shots/point. A pixel pitch is equal to that of Fig. 2. The density of energy is 350 mJ/cm^2 on an irradiated surface of a pixel.

[0025]

In the third embodiment, the pulse laser beam is moved along a direction parallel to the source line 21 for scanning. The pixel pitch in the scan direction is 210 µm. Because the scan pitch of the laser beam (21 µm) is a submultiple of the pixel

pitch in the scan direction, the overlapping region of laser irradiation is formed on the entire TFT 26 as achieved in the second embodiment. The channel width of the TFT 26 is 6 µm. Because this channel width is smaller than the scan pitch of the laser beam, in a case where a channel width direction of the TFT matches the scan direction of the laser beam, there is a significant possibility that positions in the falling edge region of the laser beam at which the laser beam is irradiated onto the semiconductor thin film vary among the substrates depending on the accuracy of laser beam alignment. Such variation in the positions of irradiation changes an effective irradiation energy history, which causes deterioration in reproducibility of the TFT characteristics. Therefore, in this embodiment, the polycrystalline silicon thin film 27 is disposed at an angle of 45 degrees with respect to the source line 21 to set the channel width direction of the TFT at an angle of 45 degrees with respect to the scan direction of the laser beam. In this manner, an intersection area of the laser beam and the channel region is extended so that the laser beam overlapping region caused by alignment deviation of the laser beam or the like always exists in the polycrystalline silicon thin film 27, which can relieve nonuniformity in the TFT characteristics. When a liquid crystal display apparatus is produced using this TFT array, unevenness of the characteristics for each TFT 26 can significantly be reduced, to thereby improve display quality. It should be noted that this effect can be achieved as long as the scan direction of the pulse laser beam intersects the channel width direction of the TFT 26 at an angle greater than or equal to 10 degrees and smaller than or equal to 90 degrees.

[0026] [Fourth Embodiment]

Fig. 4 is a layout plan view of a liquid crystal display apparatus used for explaining the method of manufacturing a liquid crystal display apparatus according to a fourth embodiment of this invention. In Fig. 4, reference numerals 21, 22 represent a source line, reference numerals 23, 24 represent a gate line, reference numeral 31 represents a driving circuit on the scan side, reference numeral 32 represents a driving circuit on the data side, and reference numeral 33 represents a display region.

[0027]

In the fourth embodiment according to the liquid crystal display apparatus, each pixel in the display region 33 has a structure similar to that of Fig. 2 or Fig. 3, furthermore the driving circuit on the scan side 31 and the driving circuit on the data side 32 are integrated in the liquid crystal display apparatus. The gate lines 23, 24 and the source lines 21, 22 are orthogonal to each other and driven by the driving circuit on the scan side 31 and the driving circuit on the data side 32, respectively. Further, a gate line direction of the TFT for driving the data side which forms the driving circuit on the data side 32 is established so as not to be parallel to the direction of the source lines 21, 22 in the display region 33, and a gate line direction of the TFT for driving the scan side which forms the driving circuit on the scan side 31 is established so as not to be parallel to the direction of the gate lines 23, 24 in the display region 33. More specifically, the channel length or width direction of the TFT which forms the driving circuits on the scan side and on the data side 31, 32 is

disposed so as not to be orthogonal to the directions of the gate lines 23, 24 and the source lines 21, 22 in the display region 33. In addition, the laser beam is moved for scanning along a direction orthogonal to the gate lines 23, 24 in the display region 33.

[0028]

By forming the TFT for the driving circuits on the scan side and the data side 31, 32 as described above, the intersection area of the channel region of the TFT for driving and the scan direction of the laser beam is extended so that the laser beam overlapping region due to the alignment deviation of the laser beam or the like always exists in the polycrystalline silicon thin film of the TFT for driving. In this manner, unevenness of the TFT characteristics decreases significantly and output unevenness from the driving circuits on the scan side and the data side 31, 32 can be suppressed, which resulted in great improvement of display quality.

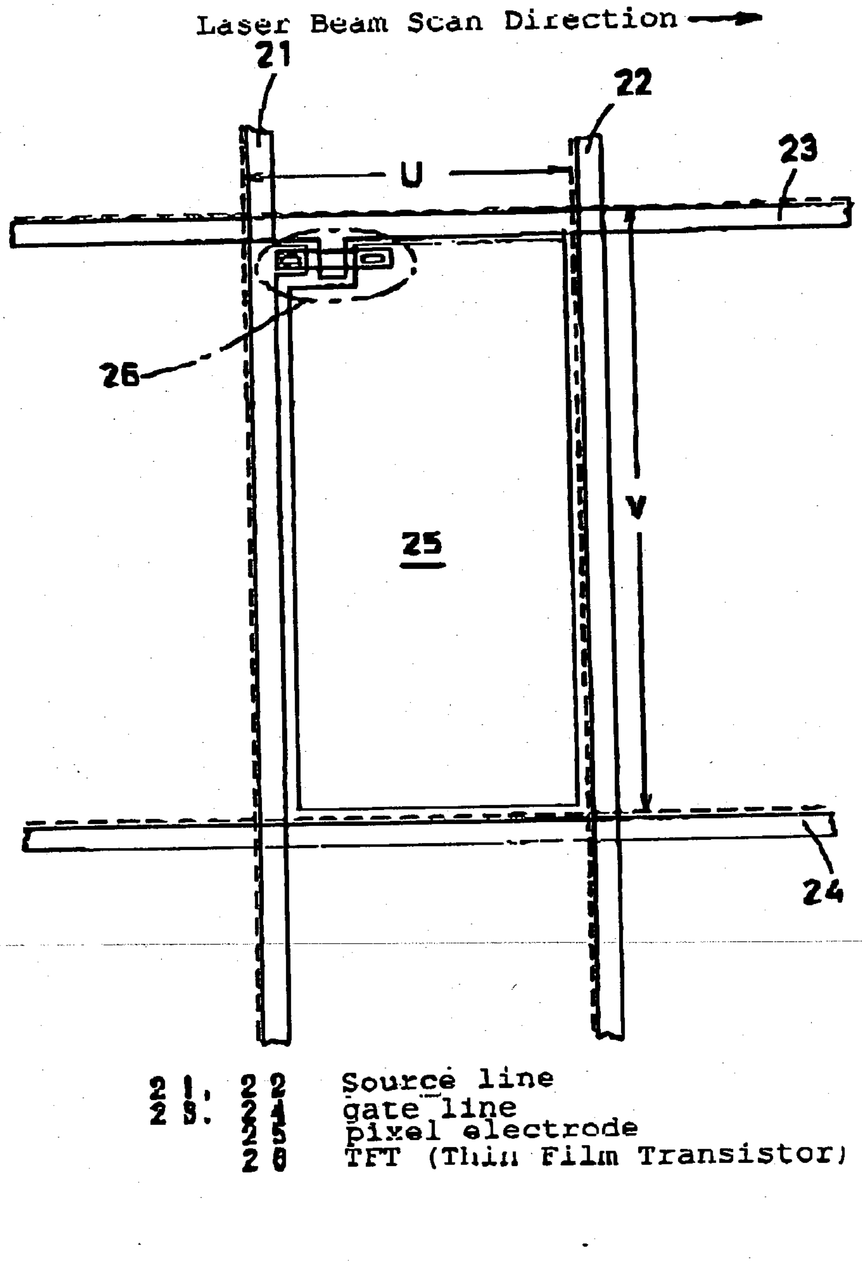
Laser Beam Scan Direction
21
22
23
U
V
26
25
24
21, 22 Source line
23, 24 gate line
25 pixel electrode
26 TFT (Thin Film Transistor)

Fig. 2

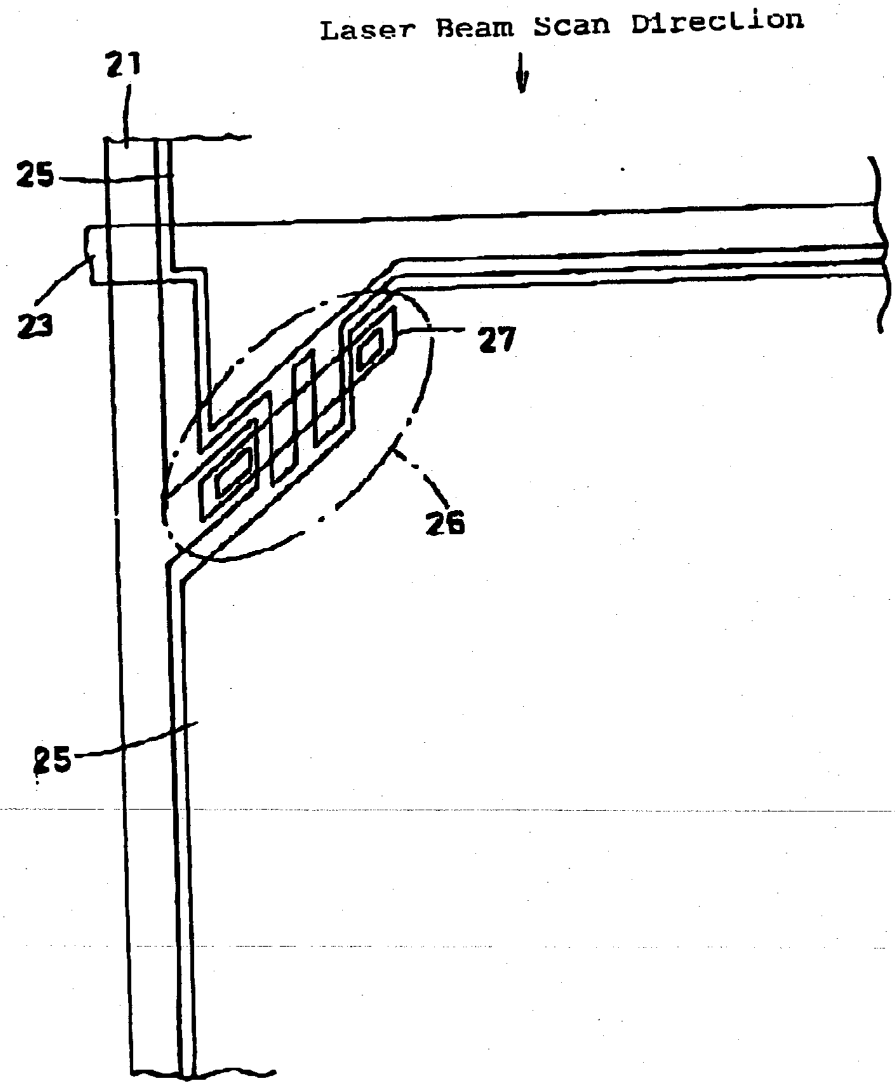

Fig. 3

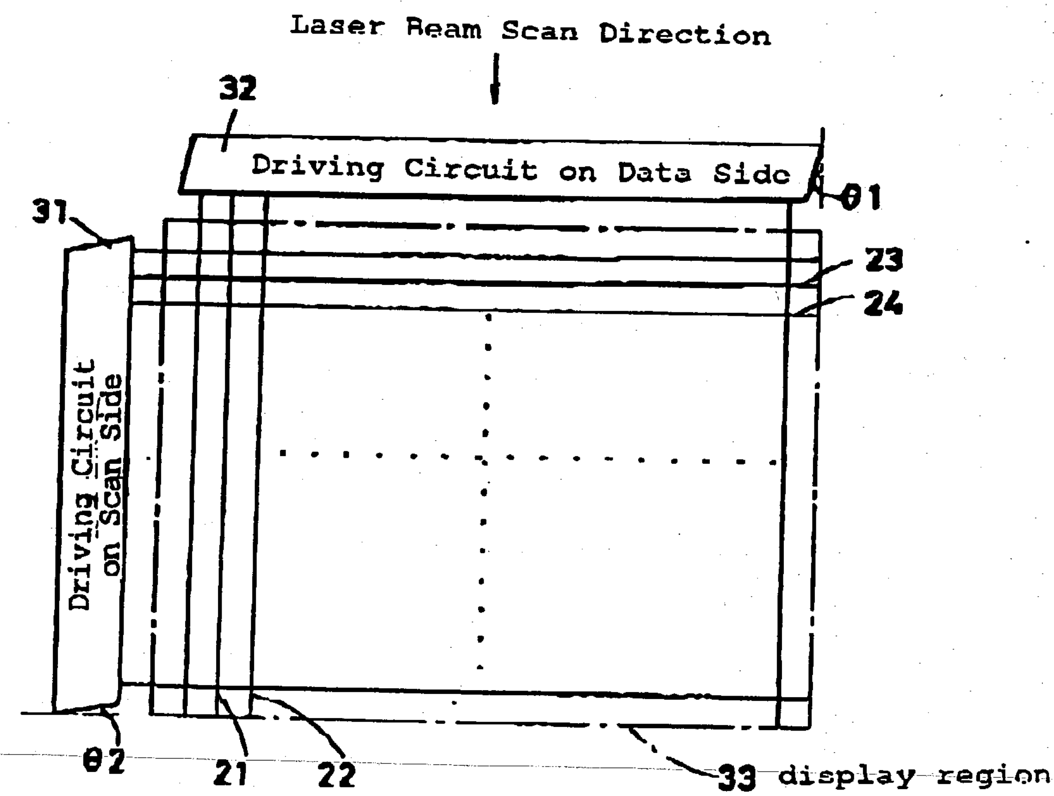
Laser Beam Scan Direction
32
Driving Circuit on Data Side
01
31
23
24
Driving Circuit on Scan Side
02
21
22
33 display region

Fig. 4